Physics 129 A
Fall 2004
Professor Freedman
November 3, 2004
Problem Set# 7 (Due: November 12, 2004)

(*These Problems are taken from Perkins Chapter 4 they are slightly out of order and your need to refer to the chapter for critical information.*)

1. Show that the additive quark models predicts the following cross-section relationships:

$$\sigma(\Lambda p) = \sigma(pp) + \sigma(K^- n) - \sigma(\pi^+ p)$$

$$\sigma(\Sigma^- p) = \sigma(pp) + \sigma(K^- p) - \sigma(\pi^- p) + 2[\sigma(K^+ n) - \sigma(K^+ p)]$$

$$\sigma(\Sigma^- n) = \sigma(pp) + \sigma(K^- p) - \sigma(\pi^- p)$$

2. Discuss the possible decay modes of the Ω^- hyperon allowed by the conservation laws, and how the weak decay is the only possibility.

3. The state $J/\psi(3100)$ has full width Γ= 87 keV and 88% of the decays are to a hadronic final state. Assume that the hadronic decay proceeds via three gluons, $\psi \rightarrow 3G$, with a rate given by the same formula as that for triplet positronium decay ($\Gamma(3\gamma) = [2(\pi^2 - 9)/9\pi]\alpha^6 m$), but with $4/3\alpha_s$ replacing α. Estimate a value for α_s from this data.

4. The radiative decay $\Upsilon(9460) \rightarrow \gamma$ + hadrons has a branching ratio of about 0.3%. The total width of the Υ is 53 keV. Using the same approach as the previous problem estimate a value for α_s from this data.

5. The 1^3S_1-1^1S_0 level separations in the ground states of the hydrogen atom, positronium e^+e^- and muonium μ^+e^- are proportional to the product of the magnetic moments of the fermions involved. From the transition frequency (1420 MHz) in hydrogen, calculate that in muonium and compare with the experimentally observed value (4463.30 MHz). For positronium, an extra factor 7/16 is present because of the contribution from an annihilation diagram not present in the other systems. Remembering to allow the reduced-mass-effects, calculate the value of the splitting of positronium and compare with the result in Table 4.4 in Perkins.

6. Verify the expressions for the magnetic moments of baryons in Perkins Table 4.12. The magnetic moments of the protons and neutron, as well as certain combinations of those of the hyperons, will depend only on the magnetic moments of the u and d quarks. Assuming each has one third of the mass of the nucleon, calculate the baryon moments (or those combinations of baryon moments that do not depend on the moments of the s quark) and compare with experimental values.